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TITLE: INTEGRATED SERVICE BASED QoS in WiMAX

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ABSTRACT

Quality Of Service in WiMAX using integrated service is one of the most active area in Computer field with the large numbers of application such as Video, audio streaming, online gaming &video conferencing . IEEE 802.16 standard commonly known as WiMAX is latest Technology that has promised to other broadband Wireless access over long distance WiMAX Network is having several QoS at Media Access Control level for voice, data & video .The problem of assuring QoS is that how to allocate available resource, admission control, scheduling among user in order to meet factor such as delay, jitter & throughput, IEEE standard doesn't include scheduling mechanism. In addition to that we are giving detail of recent scheduling research .Goal of this scheduling are to active the optimal usage of resource to assure QoS guarantees. We will present different scheduling algorithm for UGS, rtPS service class for P2MP and Mesh network to meet guarantees QOS ie delay, jitter for each packet.

Keywords: QoS, MAC, UGS ,rtPS, P2MP, Intserv

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1. INTRODUCTION

WiMAX stands for Worldwide Interoperability for Microwave Access. It is the technology aimed to provide wireless data access over long distances. It is based on Institute of Electrical and Electronics Engineers (IEEE) 802.16 standard [1] [2]. The name WiMAX was created by the WiMAX Forum, In the early 2000's, BWA in Metropolitan Areas has been recognized as one of the most promising technologies that will be widely deployed in the world. In order to rapidly converge on a worldwide standard, several standards have been published. A number of options are provided in the IEEE 802.16 family. [1] [2]

• IEEE 802.16a: The standard specifies the operation from 2GHz to 11GHz,both licensed and license exempts. Because the signals at lower frequency can penetrate barriers and thus a line-of-sight connection between the transceiver and receiver is not required, most commercial interests have focused mainly on the lower frequency ranges. Under this premise, IEEE 802.16a standard was thus completed in January 2001. It enables the WiMAX implementations with better flexibility while maintaining the data rate and transmission range. IEEE 802.16a also supports mesh deployment, which can extend the network coverage and increase the overall throughput.

• IEEE 802.16b: This extension increases the spectrum to the 5 and 6 GHz frequency bands, which provides QoS guarantee to ensure priority transmission for real-time applications and to differentiate service classes for different traffic types.

• IEEE 802.16c: As the Work Group's initial interest, IEEE 802.16c defines a 10 to 66 GHz system profile that standardizes more details of the technology. These high frequency bands have more available bandwidth, but the signals cannot diffract the obstacles and require line of sight deployment.

• IEEE 802.16d: Approved in June 2004, IEEE 802.16d upgrades the 802.16a standard. This extension aims to improve performance for 802.16 especially in the uplink traffic.

• IEEE 802.16e: This technology standardizes networking between fixed base stations (BSs) and mobile base stations (MSs), rather than just between base stations and

fixed recipients. IEEE 802.16e enables the high-speed signal handoffs necessary for communications with users moving in vehicles. It promises to support mobility up to speeds of 70-80mi/h. The subscriber stations (SSs) could be personal communication devices such as mobile phones and laptops.

1.1 Quality of Service

As packets travel within a wireless network such as WiMAX, they experience the following problems.

- Delay: Unpredictably longer time for packets to reach the destination due to unavailability of network resources.
- Jitter - Packets from source will reach the destination with different delays. This variation in delay is known as jitter and can seriously affect the quality of streaming audio and/or video.
- Out-of-order delivery: When a collection of related packets are routed through the Internet, different packets may take different routes, each resulting in a different delay. The result is that the packets arrive in a different order to the one with which they were sent. This problem necessitates special additional protocols responsible for rearranging out-of-order packets once they reach their destination.
- Packet loss or Error: Sometimes packets are misdirected, corrupted, or completely lost during transit. If the packet was dropped, the receiver has to ask the sender to resend it. In case of bit error detected in a packet, the receiver has to detect the error and, just as if the packet was dropped, ask the sender to repeat it.

1.2 QoS Mechanism

Providing efficient QoS support is essential to various networks, as they need to deliver real-time services like video, audio, and voice over IP. There are essentially two ways to provide QoS guarantees. The first is to simply provide lots of resources, enough to meet the expected peak demand with substantial safety margin. This approach generously over provisions the network. All packets get a quality of service sufficient to support applications sensitive to QoS. This approach is relatively simple, but some people believe it to be expensive in practice. It cannot cope if the peak demand increases faster than predicted. Deploying the extra resources takes time. For wireless networks, since the capacity of a wireless channel varies randomly with time, over provisioning the network for QoS support will end up resulting in waste of resources. Hence, this approach is not feasible for commercial networks.

The second approach is requiring people to make reservations, and only accept the reservations if the routers are able to serve them reliably. This is known as admission control.

To provide QoS support there are two popular methods:

1. Integrated Services (IntServ) [3]: Briefly described, IntServ is a model used for providing traffic forwarding service levels in networks. It allows for micro- flows to be created with reserved resources (such as bandwidth) and other traffic handling characteristics (maximum packet size, maximum burst size, etc.). Traffic is pushed into these microflows in the direction of the required destination. IntServ is implemented by four components: the signaling protocol (e.g. Resource reSerVation Protocol RSVP), the admission control, the classifier and the packet scheduler. Applications requiring guaranteed service or controlled-load service must set up the paths and reserve resources before transmitting their data. The admission control routines will decide whether a request for resources can be granted.After classification of packets in a specific queue, the packet scheduler will then schedule the packet to meet its QoS requirement

2. Differentiated Services (DiffServ) [4]: Briefly described, DiffServ is architecture for providing different types or levels of service for network traffic. One key characteristic of diffserv is that flows are aggregated in the network, so that core routers only need to distinguish a comparably small number of aggregated flows, even if those flows contain thousands or millions of individual flows.

The IEEE 802.16 standard includes the QoS mechanism in the MAC layer (layer 2) architecture. It defines service flows which can map to DiffServ code points. This enables end-to-end QoS. Among other things, the MAC layer is responsible for scheduling of bandwidth for different users. The MAC layer performs bandwidth allocation based on user requirements as well as their QoS profiles. The standard is designed to support a wide range of applications. These applications may require different levels of QoS. To accommodate these applications, the 802.16 standard has defined five service flow classes. They are summarized in Table 1

Class	**Description**	**Applications**
Unsolicited Grant Service (UGS)	For Constant Bit Rate (CBR) and delay- dependent applications	VOIP
Real-Time Polling Service (rtPS)	For Variable Rate and delay dependent applications	Streaming audio, Streaming video
Extended Real-Time Polling Service (ertPS)	For Variable Rate and delay dependent applications	VOIP with silence suppression
Non-real-time Polling Service (nrtPS)	Variable rate and non-real time applications	FTP
Best Effort (BE)	Best Effort	E-mail, web traffic

Table 1 WiMAX/802.16 QoS Model

2. WiMAX Architecture

The IEEE 802.16 standard was designed from the ground-up to support a P-MP (Point-to-Multipoint) wireless access architecture, allowing multiple fixed Subscriber Stations (SS) and/or Mobile Stations (MS) to be served by a single Base Station (BS), sharing the offered data rate within the cell defined by the BS. On the downlink (DL), the SSs are addressed in TDM fashion, whereas on the uplink (UL) each SS is allotted a variable length TDMA slot. Wireless broadband access based on P-MP architecture is set up like cellular systems, using Base Stations that service a radius of several miles/kilometers. Base stations do not necessarily have to reside on a tower. More often than not, the base station antenna will be located on a rooftop of a tall building or other elevated structure such as a grain silo or water tower. For Fixed WiMAX, a customer premise unit, similar to a satellite TV setup, is all it takes to connect the base station to a customer. The signal is then routed via standard Ethernet cable either directly to a single computer, or to an IEEE 802.11 (WLAN) hot spot or a wired Ethernet LAN [6]. An example P-MP Fixed WiMAX deployment configuration, showing also potential application areas, is depicted in Figure 1. For Mobile WiMAX, the mobile subscriber units (e.g. laptops, PDAs, etc.) will provide integrated WiMAX connectivity in quite the same way as commodity Wi-Fi access is provided today, but with the significant difference of much greater coverage. An example P-MP Mobile WiMAX deployment configuration, showing also the potential complementary deployment to existing Wi-Fi spots, is depicted in Figure 2.

The IEEE 802.16 standard provides also for Mesh architecture, suitable for building ad- hoc networks. In a mesh topology, the end-user terminals act also as routers for each other's traffic. Base stations are also needed to provide connections to the core network. Mesh networks offer a way to improve the coverage of a wireless access network as each new subscriber can be effectively seen as a new BS serving subscribers nearby. At the same time, however, the capacity of some links in the network might be strained. The end-user terminals are also more complex, because of the routing functionality needed. Unfortunately, the Mesh specification within IEEE 802.16 is incompatible with P-MP mode and only supports OFDM, while it leaves numerous issues unspecified. Thus, it is

questionable whether it will be used for actual implementations, at least until it is further ratified in future IEEE 802.16 standard amendments or revisions.

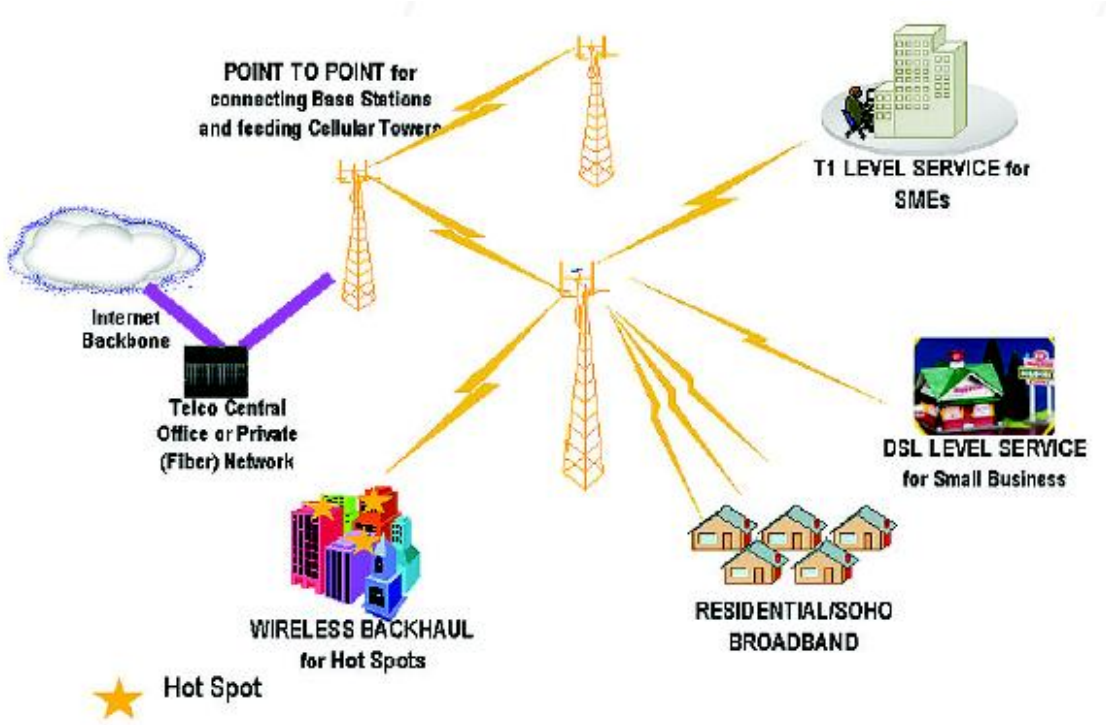

Figure 1 – Example P-MP Fixed WiMAX deployment, showing potential application areas (*source*: WiMAX Forum).

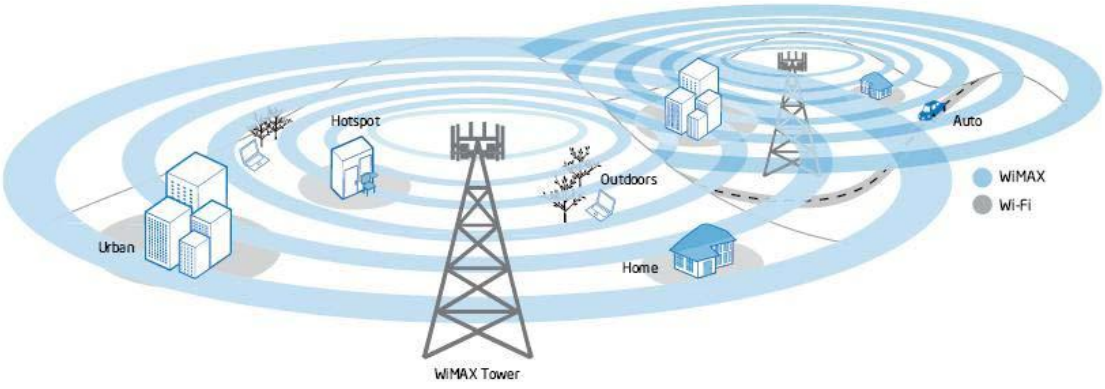

Figure 2 – Example P-MP Mobile WiMAX deployment, showing potential complementary deployment to existing Wi-Fi spots .

2.1 MAC layer details in IEEE 802.16/WiMAX network

The MAC layer of IEEE 802.16 is designed to serve sparsely distributed stations with high data rates, where the SSs are not required to listen to the other stations like the MAC in IEEE 802.11. The BS schedules the transmissions of the corresponding SSs in advance. The MAC of WiMAX is reservation-based and contention-free. The SSs need to contend only when they access the channel for the first time at the connection admission control stage. The reservation-based resource allocation allows the WiMAX BS to serve a large number of SSs as well as the guarantee of QoS in the connection level for both uplink and downlink traffic. Compared with 802.16, Wireless Local Area Networks (WLAN) based on IEEE 802.11 terminals usually have intermittent traffic that contends every time before transmitting, where the efficiency is significantly impaired when more stations enter the network. In such a contention based resource reservation scheme, QoS could hardly be considered in the early standard until the advent of 802.11e. However, most WLAN networks deployed nowadays do not employ any QoS mechanism [7].

The main purpose of the MAC protocol is the sharing of radio channel resources among multiple accesses of different users. In IEEE 802.16, the MAC layer is divided into three sublayers: the service-specific convergence, common part sublayer, and security sublayer. The primary task of service-specific convergence sublayer is to classify external service data units (SDU) and associate each of them with a proper MAC service flow identifier and connection identifier. The MAC layer protocol is flexible and efficient over different traffic types. The common part sublayer is independent of the transport mechanism, which is the kernel bearing all the MAC characteristics. It is responsible for fragmentation and segmentation of each MAC SDU into MAC protocol data units (PDUs), system access, bandwidth allocation, connection maintenance, QoS control, and scheduling transmission, etc. The MAC also contains a separate security sublayer handling authentication, secure key exchange, and encryption.

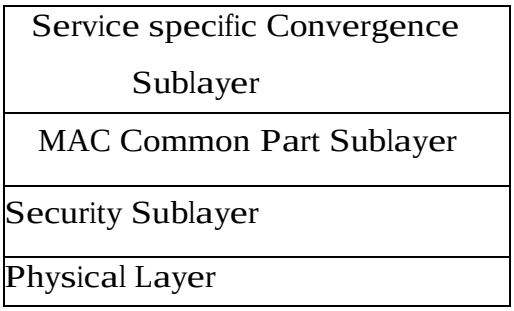

Fig. 1.3 IEEE 802.16 protocol layering

The main focus of the MAC layer is to manage the resources of the air-link in an efficient manner. MAC layer is responsible for overall connection and session processing. The MAC layers at BS and SS communicate to set up an RF connection, and to set up, add and delete services on an as needed basis. The IEEE 802.16 MAC protocol is designed to support two network models.

Point to Multipoint (PMP)
Mesh Network Model

In the PMP mode, the nodes are organized into a cellular like structure consisting of a base station (BS) and some subscriber stations (SS). The channels are divided into uplink (from SS to BS) and downlink (from BS to SS), both shared among the SS's. This type of network requires all subscriber stations to be within the transmission range. The IEEE 802.16 MAC protocol is connection oriented. Upon entering the network, each SS creates one or more connections over which their data are transmitted to and from the Base Station (BS). The MAC layer schedules the usage of the air link resources and provides Quality of Service (QoS) differentiation.

In the mesh mode, the nodes are organized in an ad-hoc fashion. All stations are peers and each node can act as routers to relay packets for its neighbors.In typical installations, there still be certain nodes that provide the BS function of connecting

the mesh network to backhaul links. However, there is no need to have direct link from SS to the BS of the mesh network. A node can choose the links with the best quality to transmit data; and with an intelligent routing protocol, the traffic can be routed to avoid the congested area.

In PMP mode, uplink (from SS to BS) and downlink (from BS to SS) data transmissions occur in separate time frames. In the downlink subframe, the BS transmits a burst of MAC protocol data units (PDUs).Since the transmission is broadcast, all SSs listen to the data transmitted by the BS. However, an SS is only required to process PDUs that are addressed to it or that are explicitly intended for all the SSs. In the uplink subframe, on the other hand, any SS transmits a burst of MAC PDUs to the BS in a time-division multiple access (TDMA) manner. SSs can be either full duplex (i.e., they can transmit and receive simultaneously) or half-duplex (i.e., they can transmit and receive at non-overlapping time intervals).

The MAC protocol is connection-oriented. All data transmissions take place in the context of connections. A connection is a unidirectional logical link between the MAC layer on the BS and the MAC layer of the SS. A service flow is mapped to a connection and the connection is associated with a level of QoS. Connections in the downlink direction are either unicast or multicast while uplink connections are always unicast. During initialization of an SS, three particular connections are established in both directions. The basic connection is used for short time critical messages. The primary management connection is used to exchange longer more delay tolerant messages. Finally the secondary management connection is intended for higher layer management messages and SS configuration data. For actual user traffic, transport connection ID's are used. For each active service for a user, two connection ID's are created. Service flows may be provisioned when an SS is installed in the system. Shortly after SS registration, transport connections are associated with these service flows. The outbound MAC then associates packets traversing the MAC interface into a service flow to be delivered over the connection. The QoS parameters associated with the service flow define the transmission ordering and scheduling on the air interface.

The connection-oriented nature of QoS can provide accurate control over the air interface. Since the air interface is usually the bottleneck, the connection-oriented QoS can effectively enable the end-to-end QoS control. The service flow parameters can be dynamically managed through MAC messages to accommodate the dynamic service demand. The concept of a service flow on a transport connection is central to the operation of the MAC protocol. Service flows provide a mechanism for uplink and downlink QoS management. In particular, they are integral to the bandwidth allocation process. An SS requests uplink bandwidth on a per connection basis (implicitly identifying the service flow through the connection ID). Bandwidth is granted by the BS to an SS as an aggregate of grants in response to per connection requests from the SS. WiMAX supports a wide range of data services and applications with varied QoS requirements.

As mentioned earlier, the IEEE 802.16 standard has defined five service flow classes which have different QoS requirements: Unsolicited Grant Service (UGS), Real-Time Polling Service (rtPS), non-Real-Time Polling Service (nrtPS), Enhanced- Real-Time Polling Service (ertPS), and best effort (BE). Each scheduling service is characterized by a mandatory set of QoS parameters, which is tailored to best describe the guarantees required by the applications that the scheduling service is designed for. Furthermore, for uplink connections, it also specifies which mechanisms to use in order to request bandwidth.

UGS is designed to support real-time applications (with strict delay requirements) that generate fixed-size data packets at periodic intervals, such as T1/E1 and VoIP without silence suppression. The guaranteed service is defined so as to closely follow the packet arrival pattern. Uplink grants are granted by the BS regardless of the current estimation of backlog; hence, UGS connections use the unsolicited granting bandwidth-request mechanism. Thus UGS connections never request bandwidth. It is given periodic bandwidth without any polling or contention. The grant size is computed by the BS based on the minimum reserved traffic rate, which is defined as the minimum amount of data transported on the connection when averaged over

time. If additional bandwidth is required, the MS may request the BS to poll it to allocated bandwidth.

rtPS is designed to support real-time applications (with less stringent delay requirements) that generate variable-size data packets at periodic intervals, such as Moving Pictures Expert Group (MPEG) video and VoIP with silence suppression. The key QoS parameters for rtPS connections are the minimum reserved traffic rate, which has the same meaning as with UGS, and the maximum latency, which upper bounds the waiting time of a packet at the MAC layer. Since the size of arriving packets with rtPS is not fixed, as it is with UGS-tailored applications, rtPS connections are required to notify the BS of their current bandwidth requirements. The BS periodically grants unicast polls to rtPS connections.

In Table 2-1, we list some of the applications belonging to each class, including suggested delay guarantees that they require under both premium and basic service [5].

Class of Service	**QoS Requirements**			**Kinds of services**
	QoS Factors	**Premium**	**Basic**	
UGS	Packet Delay	< 150ms	< 250ms	VoIP
	Delay Jitter	< 30ms	< 50ms	
	Packet Loss	< 0.3%	< 0.5%	
	Guarantee	> 99.9%	> 99.5%	
rtPS	Packet Delay	< 300ms	< 600ms	Video Telephony, Video game, VOD, AOD, Internet shopping, bank and stock transaction
	Delay Jitter	< 50ms	< 100ms	
	Packet Loss	< 1%	< 5%	
	Guarantee	> 99%	> 95%	
nrtPS	Packet Delay	N/A	N/A	High-speed file transfer, Multi- media messaging, E-commerce
	Delay Jitter	N/A	N/A	
	Packet Loss	0-2%	0-5%	
	Guarantee	> 98%	> 82%	
BE	Packet Delay/ Delay Jitter/ Packet Loss/	N/A	N/A	Web-browsing, SMS

Table 2-1: Traffic classes in 802.16 and their QoS requirements

Unlike UGS and rtPS scheduling services, nrtPS and BE are designed for applications that do not have any specific delay requirement. The main difference between the two is that nrtPS connections are reserved a minimum amount of bandwidth (by means of the minimum reserved traffic rate parameter), which can boost performance of bandwidth-intensive applications, such as File Transfer Protocol (FTP). Both nrtPS and BE uplink connections request bandwidth by either responding to broadcast polls from the BS or piggybacking a bandwidth request on an outgoing PDU.

3. STATE OF ART

Int Serv is implemented by four components: The signalling protocol (eg RSVP), the admission control, classifier & scheduling. So resource managed & scheduling issued to increase connection capacity of real time streaming in WiMAX

Resource Reservation and admission control in IEEE 802.11 WLAN : In [8] author have studied RRAC in WLAN network with the traffic course source based priority scheme (TSPS) algorithm. They have implemented system prototype lobaq to reduce latencies.

Wireless MAN IEE 802.16: In [9] the author have provided QOS for protocol based on borrowing and degradation of bandwidth model, Priority Scheduling , Request and Grant Mechanism in mesh Network. He also discusses admission control policies for certain protocol that sufficient resources are available.

Analysis of Quality of service in WiMAX Network: In [10] author have proposed various parameter that indicate QOS such as throughput, Packet loss, Average Jitter and Average Delay are analysed for different type of service flow as defined in WiMAX. The result in NS2 simulator shows that Delay parameter for voice over WiMAX, Packet Size and Line Speed do not have dominant effect on total delay. However BS range and number of BS play most decisive roll. So improving BS will provide better voice call quality in WiMAX application.

Analysis of Delay factor for voice over WiMAX: In [11], the author have analysed the effect of Packet Size, Core Network Line Speed, ISP LinkSpeed, Wireless Network Link Speed , Wireless Distance, Base Station Range the result shows that WIMAX base station and number of Base Station play the most decisive role.

Survey on mobile WiMAX: In [12], the author have told about the survey on mobile WiMAX IEEE 802.16e. Its development and QOS provisioning and mobile WiMAX specification i.e., Mac Layer in WiMAX point-to-point , point-to-multipoint and inter operability of 802.16 and IEEE802.11

Scheduling in IEEE 802.16 e mobile WIMAX Network: In [13], the author have provided the survey of recent scheduling proposal for WiMAX. The goal of scheduler are basically to meet QOS guarantee for all service class to maximize the system goodput, to maintain the fairness , to minimize power consumption. To achieve QOS EDF for rtPS and WFQ for nrTPS and WRR for interclass. Scheduler can maximize the system throughput.

Comparative assessment for Different WiMAX scheduling Algorithm: In [14] the algorithm strict priority, Round Robin, Weighted Round Robin & Weighted Fair Oueue has been investigated. A simulation study in Qual Net was used to compare the performance of each scheduler on different QOS class. Simulation of strict priority scheduler shows that throughput is high & delay is minimum for high QOS class. RR scheduler has better performance for low QOS class. WFQ+WRR can control performance of each class by assigning different weight to each queue.

Comparison of Wimax Scheduling algorithm and proposal fro rtPS QOS class: In[15] in this section the author have compared five scheduling algorithm the RR, mSIR, WRR, TRS+RR and TRS+mSIR scheduler. The auther has proposed the modified maximum signal to interference Ration (mmSIR) scheduler for rtPS class which give better mean time and also more data packets with regard to mSIR.

Comparative study of scheduling Algorithms for Wimax: In [16] the auther presents a comparative analysis of proportionate Fair (PF), cross layer & TCP – aware uplink scheduling algorithm In P.F algorithm which is scheduling priority based. But it fails to deliver QOS parameter requirement for particular connection e.g., delay, throughput. In cross layer scheduling algorithm OQS Gurantee, Channel Quality is also considered for scheduling but it is difficult to implement all slot per frame are allotted for highest priority connection. In TCP aware uplink scheduling algorithm which is very efficient to utilize the resource among BE connection. We can implement one algorithm and used for improving its performance is term of delay, throughput and other QOS parameter.

Packet Scheduling to Enhance Quality of Service in IEEE 802.16 : In [17] writer has studied scheduling algorithm for providing Qos in wireless broadband are Earliest deadline first (EDF) & Weighted Fair Queuing (WFO). He has proposed combination of both EDF+WFQ technique to allocate bandwidth so that lower priority traffic don't starve. In this paper improvement in BE traffic class when traffic of rtPS class is high.

Analysis and modification of scheduling algorithm for IEEE802.16: In [18] author have studied Round Robin (RR), Deficit Round Robin (DRR) and proposed his Modified Deficit Round Robin (MDRR) algorithm in which there are two type of MDRR scheme.

Alternate Mode: In this mode high priority Queue is serviced in between every other Queue (PQ, Q1, PQ Q2, PQ Q3, PQ & Q4)

Strict Priority Mode: Here the high priority Queue is served whenever there is backlog after transmitting all its packet then the other Queue are served.

With this MDRR algorithm the author has attempted to enhance the throughput of system with regard to channel quality.

Research an improve of scheduling algorithm of Bandwidth allocation for WiMAX: In[19] author have used adaptive rt PS algorithm and shows the simulation that delay of real time communication has provided a good protection with the traditional adaptive rtPS scheduling

solution compared to bandwidth allocation at a time, but also take in account the business data in better Queue length so as to reduce the real time operational delay, reducing the demand Oueue length

Ensuring the Qos requirement in 802.16 scheduling: In [20] author have used Round Robin Scheduling algorithm for 802.16 BS to ensure the Qos requirement of SS in uplink & downlink direction. In his scheduling he has calculated minimum No of slots, unused slot allocation & order of slot to decrease this Jitter in NS-2 simulation.

Scheduling and Call Admission Control Algorithm for Wimax Mesh Network with Strict Qos Guarantee: In [21] the author have studied routing and centralised scheduling algorithm for UGS & rtPS class in mesh network. He has taken the idea of centralized scheduling algorithm of splitting the request into two parts. The first part takes care of delay constraint and not worry about jitter constraint where the second part is responsible for jitter constraint.He has proposed CAC algorithm which works with scheduling algorithm to make sure that every pocket meets its delay and jitter requirement. He has also proposed method for allocated extra bandwidth to rtPS request.

End to End QoS Aware Greedy Distributed Scheduling Frame work for Wimax Mesh Network: In [22] the author have studied Race free protocol (RFP) & proposed Greedy Forwarded algorithm used by End to End Qos aware bandwidth Reservation Protocol (EQRP) which more efficient then the flooding approach used by RFP. EQRP is capable of admitted more call in Comparison with RFP. In comparison with RFP EQRP took 200 milli-second less average call setup time.

4. OBJECTIVE

WiMAX is one of the most promising broadband wireless technologies today. The WiMAX standard IEEE 802.16 is designed to provide Quality of Service (QoS) to delay—sensitive traffic like video and voice. However, the standard does not specify any particular scheduling algorithm to achieve the above objective. This varous algorithm and scheduling scheme for providing QoS to uplink traffic and downlink traffic i.e. traffic transmission from the base station (BS) to the subscriber stations (SS) in WiMAX. The primary objective in designing the scheduling scheme is to provide each traffic type with appropriate resources such that it meets its average packet delay,jitter and average packet loss criteria. Extensive simulations will be performed to test scheduling algorithm. We will show that our Simulation results and our scheduling scheme minimizes the packet loss and almost always meets the average packet delay constraint even in a heavily loaded network.

5. RESEARCH METHODOLOGY

Scheduling algorithms serve as an important component in any communication network to satisfy the QoS requirements. The design is especially challenged by the limited capacity and dynamic channel status that are inherent in wireless communication systems. To design an MAC layer protocol which can optimize the system performance, the following features and criteria should be concerned.

QoS requirements

The proposed algorithm should support different applications to exploit better QoS. To support delay-sensitive applications, the algorithm provides the delay bound provisioning. The long-term throughput should be guaranteed for all connections when the sufficient bandwidth is provided.

Bandwidth utilization

Efficient bandwidth utilization is the most important in the algorithm design. The algorithm must utilize the channel efficiently. This implies that the scheduler should not assign a transmission slot to a connection with a currently bad link.

Fairness

The algorithm should assign available resource fairly across connections. The fairness should be provided for both short term and long term. .

Scalability

The algorithm should operate efficiently as the number of connections or users sharing the channel increases

6. SIGNIFICANCE

The admission control and Resource Management of WiMAX make it suitable for the following potential applications:

- Providing portable mobile broadband connectivity across cities and countries through a variety of devices.
- Providing a wireless alternative to cable and DSL for "last mile" broadband access.
- Providing data, telecommunications (VoIP) and IPTV services

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